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THE PROFESSIONAL SCHOOL.*

BY CHARLES R. MANN,

Washington, D. C.

The American people have a profound faith in education. Though they may not always comprehend school processes and are not always pleased with the product of the schools, they trust education implicitly. Especially since the war, education has been extolled as the great national specific for industrial unrest, for profiteering, for bolshevism, for illiteracy, and for the total depravity of things in general. It is, therefore, fitting at the inauguration of a new administration in a great state university like this to study the situation and seek to define more clearly the ultimate objectives we are striving to attain.

Because of its reverence for the inscrutable processes of schooling, the public instinctively looks to universities for leadership in all matters of training. Therefore the university, whether it be formally recognized as the head of the school system or not, is in fact the arbiter of the fashions of the lower school. Since the graduate or professional school is now the cap and climax of the university, its influence exerted either consciously or unconsciously, is paramount in determining the ends, aims, policies, and processes of the whole system. Legally constituted officials of public school systems usually deny this: and superficially and explicitly they are right. But searching analysis generally reveals the fact that universities still dominate subconsciously and implicitly, as they should.

The responsibility that rests upon universities in general,

* Address delivered at inauguration of Harry Woodburn Chase as president, University of North Carolina, April 28, 1920.

and on graduates and professional schools in particular, because of their intuitively accepted position of spiritual and intellectual leadership is impressive. These institutions still appeal strongly to the national imagination and are still able to direct the constructive energies of the people one way or another by the force of their ideas. Hence it is particularly important in these days of confusion after the world cataclysm that the professional schools conceive their mission clearly and proceed to execute it fearlessly and with vigor.

During the past forty years great progress has been made in elevating the standards of the professional schools. The entrance requirements have been raised from high school graduation to at least two years of college work. Laboratories and equipment have multiplied rapidly. Clinics and the case system have been developed. Full-time professorships have been established and many superb buildings have been built. The requirements for admission to the bar and for medical practitioners' licenses have steadily advanced.

This development of the paraphernalia and technique of training has been accompanied by a corresponding increase in technical skill. The physician, the lawyer, or the engineer of today can perform feats which their colleagues of forty years ago would have pronounced impossible. In the schools both instructors and students have worked with increasing interest and enthusiasm to perfect themselves and to master the special subjects of their choice.

All of this has been magnificent and everyone concerned has felt pride and satisfaction in the progress that has been made. And when the great crisis came and we were called upon to try our strength in the world struggle, this mastery of the mysteries of medicine, of science, of engineering, and of law was an indispensable factor in our success. Without it the nation would have perished.

But the world war opened our eyes to a new vision. However satisfied and contented we were before the struggle, there was a thrill and an inspiration about the war work that made every man who served able to do more work and better work

than ever before. There was a resurrection of the pioneer soul of our forefathers, a release of the spirit of service and sacrifice which converted a relatively humdrum existence into a life of reality and grim adventure. The joy and tragedy of it permeated every household. We lived as a united nation for a few months. Then the crisis passed and we settled down once more into commonplace routine.

No one wants war. Yet millions feel that life would be better if the spirit of service and sacrifice that prevailed during the war would continue to prevail in time of peace. Nor is it inconceivable that this might be so. The problems and perplexities of peace, though less dangerous to life and limb, are no less difficult of solution. Their mastery is no less a challenge to the soldierly virtues, as defined by William James in his "Moral Equivalent of War," than is the winning of a battle or the conquering of a continent. Because they are less spectacular, they demand even greater determination, resourcefulness and the endurance that makes defeat impossible.

Whether the national spirit of service remains free and active or is again pent up until released by the next war, depends largely upon public education. And since the tone and attitude of public education is intrinsically determined by the professional schools, there exists at the present moment for these schools the finest opportunity that ever came to any institution to contribute to the upbuilding of a democratic nation. Quick action will bring larger returns because the crust of the commonplace is rapidly forming over the pioneer spirit: and the thicker the crust, the harder to shatter it and liberate the creative energy within.

Like all elemental things, the thing that needs doing is very simple. It consists in first searching out the fundamental distinction between teaching as it is and teaching as it must be to produce the desired result, and then modifying curricula and instruction accordingly. As a beginning of this search it is suggested for discussion that the fundamental distinction sought may be thus expressed: current schooling is consciously

designed to inspire the individual to make the most of himself for his own satisfaction. The desired schooling must inspire him to make the most of himself for the common good.

The former leads the student to think in terms of competition—of doing the other fellow. It gives rise to such ever present expressions as "what do I get out of it?" and "I should worry." The latter emphasizes coöperation, develops team-play and is expressed in the motto "United we stand, divided we fall." The former encourages working for wages and profits, the latter makes the joy of production uppermost and demands the just apportionment of rewards.

A practical example will help to make this distinction clearer. The design of a warehouse is a typical project in the professional courses as now given in engineering schools. The student is given in class a verbal or written specification of the conditions to be met—the nature of the chosen site, the transportation facilities, the size, the load to be carried and the limits of cost. He then goes to work with pencil and paper, under the guidance of the instructor, to make a plan. In the process he looks up necessary data in standard tables and learns much about the uses of various materials and about standard practises in warehouse construction. The work is criticized by the instructor but the building is never built.

From paper problems such as these the prospective engineer gains much technical information and a fair degree of technical skill in drawing and figuring. His imagination is given a chance to function and his ingenuity is put to the test. As a result he is better prepared to undertake a similar piece of work for an industrial firm or to secure work in an engineer's office. Through a series of similar exercises he ultimately becomes a technical expert who can earn his living in an eminently useful calling. Still, the fact remains that very few of the graduates of engineering schools win recognition as professional men.

For the past five or six years the National Engineering Societies have been actively discussing the question why the

engineer has not yet won a well-recognized professional status. It is pointed out, for example that when a state highway commission is appointed, bankers, business men and politicians generally make up its membership. These men decide what expenditures will yield to the public the largest values in good roads: and, having decided this, they hire engineers, on whose technical skill the good construction of the road depends, to do the work. This is but one of the typical cases which have driven home to engineers the fact that they are too often regarded as technicians rather than as professional men. Hence comes the inquiry why it is that current engineering training fails so often to beget a true professional spirit. No generally accepted answer to the question has yet been given.

By way of answer to the foregoing question many fruitful suggestions have been born of the spirit liberated by the war. For example, suppose that in contrast with the current type of work just described the professional studies in engineering schools were directed toward solving the problem of making the immediate environment of the school the best possible place in which to live. Instead of merely learning the technique of material construction, the student would investigate such municipal services as the water supply, transportation. electric light and power, markets, food supply, sewerage, disposal of waste, or any other of the many activities that contribute to the physical comfort of communities. The prospective engineer would then be compelled to appraise the operation of all these agencies, both in terms of public value in proportion to cost and in terms of scientific and technical perfection. He would have to recommend changes in existing plants, to project and design new construction and to suggest reorganization of present systems of transportation, marketing, heating, lighting, and the like. He would thus be constantly solving not only the problem of material construction, which usually occupy practically all the time in current instruction, but also those more fundamental problems of relative values and costs from the point of view of public welfare.

This idea is not new. About forty years ago, a professor of

civil engineering at Columbia University aroused by his own observation of the inconvenience of transportation in New York, set himself the problem of working out a system of rapid transit. He studied this problem himself and for a number of successive years set portions of the problem as exercises for the senior class. Eventually one student developed a profound interest in the study and that young man became the chief engineer of the subway system. Other schools have made similar studies to a limited extent and in every case they have found that students work with a new spirit on projects of this kind. Not only do they learn rapidly, but they also secure some conception of the complexity of the problems of values and costs. In addition they experience the joy of contributing by constructive work toward making the community a better place to live in.

Problems of the sort suggested exist in plenty in every community, large or small. The delivery system in a small town is usually a splendid example of inefficiency and waste. There are perhaps three or four groceries and markets, each of which maintains a complete system of delivery to all parts of the town. Wagons make long trips with few parcels. An organization of the delivery system could easily be made, much to the benefit of both consumer and dealer. Similarly, in large cities like New York, Boston, or Chicago, traffic is almost impossible during the working hours because of the lack of system and organization in the handling of freight. Coöperation, careful planning, a good system could reduce the congestion, reduce cost and expedite the handling of goods. Individual dealers are not likely to take the initiative in developing such a coöperative system; but a simple and sensible scheme, worked out solely from the standpoint of public welfare by a disinterested institution, would have a large chance of being accepted and quickly put into effect.

This type of problem which has been suggested as an effective means of developing a spirit of service in graduate schools is not limited to the field of engineering. The sanitary condi-

tions and the training of communities to better methods of living to preserve health offer opportunities of infinite possibilities to the medical schools. A great deal has already been done in this direction. Similarly in the field of law. No one can read the recent report on Justice and the Poor, or study the operation of our petty courts without being impressed with the fact that an unbiased study of the processes of justice in any community, when carried on from the point of view of public welfare, would yield enormous returns in making happier, more contented and more productive citizens.

The possibilities in the way of developing the spirit of service, which is after all the true professional spirit, through service of the public are without bound. Suppose that a great state university like this should set itself the problem of determining how this state could be made more productive and in every way a better place to live in. Instead of confining its efforts largely to developing technical skill and imparting information to its students, the institution would organize its instruction so that students would secure their technical skill by solving problems of vital interest to the state. What are the mineral resources of this state and what steps might be taken to utilize them for the public benefit? Are the industrial resources of this state fully developed? What incentives could be applied to stir local initiative for their further development? The great project of building state highways is being formulated. How can this achievement be coördinated with industrial production so as to yield the greatest returns to the people of the state? What measures of public health and what legal enactments would tend to improve sanitary conditions and commercial activities? If a state university like this should undertake to make practical scientific studies of problems like this, and if it should always cling close to the idea of public welfare, it is safe to predict that larger appropriations would soon solve the problem of teachers' salaries, that a finer and freer professional spirit would burst forth among the students and that the creative

energies of the state would be released in greater production. All this would inevitably result in greater prosperity and a loyalty to the commonwealth and the nation equal to that called forth by the war.

The adventure suggested in the foregoing remarks, though thoroughly in harmony with American ideals of democracy and self-government, requires a daring spirit on the part of professional schools. A single institution would indeed have great moral courage in order to undertake it alone and carry it through to a successful conclusion. On the other hand, the possible returns are enormous. The spirit of service and sacrifice is contagious: it is, perhaps, one of the instinctive motives of men. It operates with a power that brooks no defeat. If the cultivation of that spirit were sanctioned by professional schools as the distinguishing mark of the professional man, the lower schools would rapidly follow suit. Then creative imagination would find freer fields for exercise, pent up energies would be released in constructive work, and there would be more artists and fewer artisans, more scholarship and less scholasticism.

A professional school surely does not realize its true destiny when it is merely a factory for quantity production of standardized technical and intellectual skill. Professional attainments can not be gauged with a stop watch or measured in terms of student clock hours or semesters. Nor are these practices longer needed. University professors were assigned by the hundred to positions of great professional responsibility in the war organization. They have demonstrated their competency as experts in developing the machinery of destruction and death. Surely they are no less capable of leadership in discovering more intelligent processes of production and life.

The task is tremendous. One university entering this contest alone might find hard sledding ahead and be homesick and lonesome at times. For although the practices of universities have been drifting in this direction for a number of years, in-

dividual efforts without coöperation and mutual support generally yield meager results. There is needed a mutual moral support through the coördination of all such individual efforts. Such coördination could be applied by a national university, which would function as a center for the development of the professional spirit in the manner just described.

Such a national university would give no formal instruction as such. It would grant no degrees. Its students would be the experts from all other schools, who would be called for short periods to assist in studying national problems from the point of view of public welfare in the manner described. It would assist state institutions in defining and allocating their local problems and would supply information that would help in their solution. A national university of this kind would in no wise interfere with the control of education by the states or with the free development of schools by the public locally. It would, however, set standards of achievement, supply the vision of what might be, and furnish incentives which would inspire all educational institutions and cause them to work with a spirit of service and sacrifice for the expression of their entire creative energy in all forms of artistic productive work for the public good.

AGREED-UPON UNITS IN MECHANICS.

By E. V. HUNTINGTON,

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The repeatedly alleged "confusion about the fundamental units in mechanics" seems to me one of the most unfortunate circumstances connected with our engineering education. Here is a great underlying science, almost as old as mathematics itself, and supposedly almost as rigorous in its logical development; and yet the doctors in that science disagree, it is said, on the meaning of its fundamental terms! Truly an edifying spectacle! No wonder that the question is repeatedly raised: "How can agreement be reached?"*

I venture to suggest a very simple answer to this question. *Let us reach an agreement by simply agreeing to agree on those statements on which every one agrees already.*

Now it is astonishing how many undisputed statements can be made in this much-debated subject. I will beg the reader to examine, for example, the following list of 15 such statements, with the point of view of judging, not whether these statements are desirable or useful, but merely whether they are *true*. If it appears, as I believe it will, that all these statements would be admitted as *true propositions* in even the most diverse systems of instruction in mechanics, then we shall have a basis of common understanding from which excursions into disputed territory can later be made if desired.

* The most recent article on this subject is by W. S. Franklin and Barry McNutt, entitled: "The Simple Facts Concerning Units in Mechanics: How Can Agreement be Reached?" *Engineering Education*, October, 1920, pp. 67–71. These authors have nothing better to offer than a renewed insistence on the importance of "dividing mass in pounds by 32.174 to give slugs."

I shall group these statements, for convenience, according to subject-matter.†

On the Units of Force.

1. A *force* can be measured by the amount it stretches a standard spring. Any force having been selected as a unit force, it is easy to calibrate a standard spring so as to read multiples and sub-multiples of that unit. The principal units of force are the kilogram-force and the pound-force.

2. The *kilogram force* (1 kg.) is the force required to support (that is, prevent from falling) a certain carefully preserved lump of metal called the "international standard kilogram," in vacuo, in the standard locality. (The *standard locality,* has been fixed by the International Bureau of Weights and Measures, Paris, 1901, as any locality where $g = g_o =$ 980.665 cm./sec.^{2} = 32.1740 ft./sec.^{2}, this being approximately the value of g at 45° latitude, sea level.)

3. The *pound force* (1 lb.) is the force required to support another carefully preserved lump of metal called the "standard pound avoirdupois," in vacuo, in the standard locality.

4. According to the Bureau of Standards,

$$1 \text{ lb.} = 0.4535924277 \text{ kg.}$$

All other units of force are expressible in terms of these. Thus, 1 dyne = (1/980665) kg. (force); 1 short ton = 2000 lbs.; 1 poundal = (1/32.1740) lb.; 1 stone = 14 lbs.; etc.

On the Weight of a Body.

5. The force required to support a body, in vacuo, in the standard locality, may, if desired, be called the *standard weight* of that body. For example, the standard weight of

† See E. V. Huntington, "Recommendations Concerning the Units of Force," Bulletin of the Society for the Promotion of Engineering Education, Vol. 3, pp. 678–689, June, 1913; also "The Logical Skeleton of Elementary Dynamics," *American Mathematical Monthly,* Vol. 24, pp. 1–16, January, 1917, reprinted in *Engineering Education,* Vol. 7, pp. 546–570, May, 1917.

the lump of metal called the "standard pound avoirdupois" is the force of 1 lb.

6. If two bodies *balance* each other on an equal-arm beam-balance, anywhere, they will have the *same standard weight.* Hence the standard weight of a body can be found, anywhere, by balancing the body on a beam-balance, aginst a standardized set of metal pieces each of which is stamped with its known standard weight.

7. If $W =$ the *local weight* of a body (that is, the force required to support it, in vacuo, in any given locality), and $g =$ the local value of g, then the equation

$$W/g = W_o/g_o,$$

where $W_o =$ the standard weight of the body, and $g_o =$ the standard value of g, is a true equation. Hence, the local weight of a body can be found either directly, by suspending the body on a standard spring balance, or, indirectly, by first finding the local value of g and then computing W from the equation $W/g = W_o/g_o$.

Since standard weight (or local weight) as here defined is a force, no special "units of weight" are called for, other than the ordinary units of force (1 kg. and 1 lb.)

On Units of Pressure and Density.

8. If *pressure* means *force per unit area,* the obvious units of pressure will be the kilogram per square centimeter, the pound per square inch, etc.

9. If *density* means *standard weight per unit volume,* the obvious units of density will be the kilogram per cubic meter, the pound per cubic foot, etc. Thus, miltiplying volume by density will give standard weight.

On the Fundamental Equation Connecting Force and Acceleration.

10. If a force, F, acts on any free particle of matter, it will give that particle an acceleration, a, in the direction of the

force; moreover, if W_0 is the standard weight of the particle and g_0 is the standard value of g, then the following equation will be true:

$$\frac{F}{W_0} = \frac{a}{g_0} \quad \text{or} \quad F = \frac{W_0}{g_0} a.$$

Hence, if we know the standard weight of a particle, we can predict the acceleration (a) which any given force (F) will produce in that particle. In other words, *the dynamical properties of a particle are known whenever its standard weight is known.*

Note.—In view of 7, the equation may also be written $F/W = a/g$, or $F = (W/g)a$.*

On Units of Momentum and of Energy.

11. If a constant force F acts on particle W initially at rest, the fundamental equation $F = (W/g)\ dv/dt$, when multiplied by dt, or by dx, integrates into

$$Ft = \frac{W}{g} v \quad \text{or} \quad Fx = \frac{W}{g} \frac{v^2}{2},$$

These equations provide the motive for the following definitions.

12. The *impulse of a constant force* F, during any interval, is Ft, where t is the length of the interval.

The *momentum of a particle* W, at any instant, is

$$\frac{W}{g} v,$$

where $v =$ the path velocity of the particle at that instant.

The principal units of impulse (or momentum) are ob-

* The ratio W/g, or F/a, may, if desired, be called the *inertia* of the given particle, the principal units of inertia being obviously 1 kg. per (cm./sec.^{2}) and 1 lb. per (ft./sec.^{2}). Thus, if the inertia of a particle is said to be 5 lb. per (ft./sec.^{2}), this means simply that a force of 5 lb. would be required to give the particle an acceleration of 1 ft./sec.^{2} Hence, the dynamical properties of a particle are known whenever *either* its standard weight *or* its inertia is given.

viously the *kilogram-second* and the *pound-second* (that is, force $\times$ time). For example, if $W = 40$ lb., $g = 32$ ft./sec.^{2}, and $v = 4$ ft./sec., then the momentum

$$= \frac{40 \text{ lb. sec.}^2 \, 4 \text{ ft.}}{32 \text{ ft. sec.}} = 5 \text{ lb.-sec.}$$

13. The *work done by a constant force* F during any interval is $F\,x$, where x is the distance moved by the point of application of the force, in the direction of the force.

The *kinetic energy of a particle*, W, at any instant, is

$$\frac{W}{g}\frac{v^2}{2},$$

where $v =$ the path velocity of the particle at that instant.

The principal units of work (or kinetic energy) are obviously the *kilogram-meter* and the *foot-pound* (that is, force $\times$ distance). For example, if $W = 40$ lb., $g = 32$ ft./sec.^{2}, and $v = 4$ ft./sec., then the kinetic energy

$$= \frac{40 \text{ lb. sec.}^2 \, 16 \text{ ft.}^2}{32 \text{ ft. } 2 \text{ sec.}^2} = 10 \text{ ft. lb.}$$

Note.—1 erg $=$ 1 dyne-centimeter.

On the Equation of Rotation.

14. The equation of rotation about a fixed axis may be written, if desired, in the form:

$$\Sigma(Fp) = \frac{W}{g}k^2\frac{d\omega}{dt},$$

where $\Sigma(Fp) =$ the sum of the moments of the external forces about the given axis, $k =$ the radius of gyration about that axis, and $\omega = d\theta/dt =$ the angular velocity of the body (θ being the radian measure of the angle which a line fixed in the body makes with a line fixed in the plane).*

* The left-hand side of this equation may be called the *torque* of the applied forces, and the expression $(W/g)k^2$ the *moment of inertia* of the given body (about the given axis), the unit in each case, in terms of the fundamental units of force, length, and time, being obvious from the structure of the expression.

On the Use of the Term Mass.

15. The term *mass* is used in several different senses by writers on mechanics.* This much can always be counted on, however: if a body is described as being "a 5 pound mass," or as "having a mass of 5 lb.," or as "containing 5 pounds of matter," we can safely infer that the standard weight of the body is 5 lb. Similarly, a "mass of 10 kilograms" can safely be interpreted to mean a body whose standard weight is 10 kg.

Conclusion.

The foregoing fifteen statements (which have been carefully worded so as to avoid the use of any ambiguous or unusual terms) would be admitted, I believe, as *true propositions* in any system of instruction in mechanics with which I am acquainted. To be sure, there would doubtless be much difference of opinion as to their usefulness or desirability; but whatever attacks may be made upon them on moral or pedagogical grounds, I believe their abstract truth would not be denied.

Now suppose, for the sake of argument, that these fifteen statements are taken (as I have taken them for many years) as the starting point of a course in mechanics; *what other, perhaps more debatable, statements about units must be included before the student can solve dynamical problems successfully?*

For example, what must be known about "slugs" and "sugar-pounds" and "gee-pounds"? About the distinction between "gravitational units" and "absolute units"? About mass as "quantity of matter" in the equation $F = ma$*? About the necessity of measuring all forces in "poundals" or

* For a confirmation of this statement through exact citations from a large number of recent authors, see E. V. Huntington, "Bibliographical Note on the Use of the Word Mass in Current Text-books," *Amer. Math. Monthly*, Vol. 15, pp. 1–15, January, 1918.

* The term "quantity of matter" as used by many writers is entirely without meaning. See pages 7–9 of the "Bibliographical Note" above cited.

"dynes" if the equation $F = ma$ (peace to its ashes)! is to give the right answer? About the rules for dividing (or multiplying) the answer by "g"? About "pounds (abs.)" and "pounds (grav.)"? About "mass moments of inertia of J_m pound (grav.)-feet squared" as distinguished from the "weight moment of inertia of J_w pound (abs.)-feet squared" (or whatever the latest jargon may be)?* In short, what must be known about all the restrictions imposed by various so-called "systems of units"?

The answer is: *Nothing whatever!* The simple, undisputed statements listed above are entirely sufficient. All the other matters about which there is so much controversy can be simply forgotten. Like all controversial matters, they may indeed have a certain historical or human interest; but from the point of view of mastering dynamical problems, they are as superfluous as they are confusing.

* R. G. Hardson, The Engineers' Manual, 1917, p. 96.

UNITS IN MECHANICS.

By W. H. SCHURMAN,

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Every one I presume will agree that there are four fundamental quantities in Mechanics—length, mass, time and force—and that each of these quantities is different in kind from each and every one of the other three. Now a quantity of one kind can not be expressed as numerical multiple of a quantity of an entirely different kind; the conclusion seems evident therefore that no one of the four fundamental quantities can be expressed in terms of the other three. Yet physicists of the highest eminence have by a simple choice of the unit of force and a lack of that "precision of thought" which Professors Franklin and McNutt speak of in their paper in the October Bulletin, reduced the unit of force to a derived unit and reduced the number of fundamental units to three and claim to be able to define all other units in terms of these three.

Before pointing out the error in this reduction, let us examine one or two absurdities to which the unprecise thinking of the physicist leads. The physicist defines the unit force as that force which will produce a unit acceleration when acting on a unit mass and from this derives the equation $f_1 = m_1 a$ where f_1 is any force, m_1 the mass of the particle acted on and a the acceleration produced. The dimensions of a force are therefore $[LMT^{-2}]$ (centimeter-grammes per second per second in the C.G.S. system of units). The astronomer defines the unit of force as the mutual attractive force between two unit masses at unit distance apart and derives the equation $f_2 = m_2 m'_2 \div r^2$ where f_2 is the mutually attractive force between m_2 and m'_2 distant r from each other, and the dimensions of this force are $[M^2L^{-2}]$.

Now force in astronomy is of the same kind as force in physics; the ratio of two quantities of the same kind is necessarily an abstract number but the ratio of f_1 to f_2 is a quantity of the dimensions $[M^{-1}L^3T^{-2}]$. Maxwell reasons from this that the dimensions of M must be $[L^3T^{-2}]$, a velocity squared times a length.* This would make $[M]$ a derived unit and reduce the number of fundamental units to two.

Again in physics we have the electrostatic and the electromagnetic units of electricity; these units of electricity are quantities of the same kind and their ratio should be an abstract number; but Maxwell proves to his own satisfaction and that of succeeding physicists that this ratio is a quantity of dimensions $[LT^{-2}]$—a velocity. Had Maxwell pursued the same line of reasoning he did in Art. 5 of his treatise, referred to above, he would have concluded that the dimensions of L must be $[T]$ and the unit of length would be a derived unit and the number of fundamental units would be reduced to one. Thus if the physicist's reasoning were correct, by a mere choice of units for force, mass and length, we would only require one fundamental unit.

Now what is the trouble with the physicist's reasoning? The first paragraph in Maxwell's "Treatise on Electricity and Magnetism" is

> Every expression of a Quantity consists of two factors or components. One of these is the name of a certain known quantity of the same kind as the quantity to be expressed, which is taken as a standard of reference. The other component is the number of times the standard is to be taken in order to make up the required quantity. The standard quantity is technically called the Unit, and the number is called the Numerical Value of the quantity.

The physicist has confused his numerical value and unit. The equivalent of Newton's Second Law of Motion is that the acceleration a, produced by a force f on a mass m is directly proportional to the magnitude of the force f and inversely proportional to the mass m. This leads to the equation

* *Electricity and Magnetism*, Art. 5, p. 4, edition of 1881 .

$f = kma$, in which k is some constant. Now suppose we define the unit force as the force which will produce unit acceleration in a unit mass, then the numerical value of k will be one and the number of units of force in f will be the number of units of mass in m times the number of units of acceleration in a but the dimension of f is $[F]$ and nothing else, $[F]$ representing the unit of force as $[L]$, $[M]$ and $[T]$ represent the units of length, mass and time respectively. Thus in the C.G.S. system if a force is 6 but it is 6 dynes and not 6 centimeter grammes per second per second. In fact while k above has a numerical value of 1 when the unit force defined above is taken, its dimensions are $[FM^{-1}LT^{-2}]$ and it is not an abstract number as physicists have assumed. The C.G.S. system should be called the C.G.S.D. system and it really has four fundamental units.

In astronomy the Newtonian Law of gravitation can be expressed as $fr^2 \div k'mm'$ and by adopting the unit force as that between two unit masses at a unit distance apart, the numerical value of k' is one but the dimensions of k' are $[FL^2M^{-2}]$. With the dimensions of k and k' given above, the ratio of the astronomical unit of force to the physical unit is an abstract quantity as it should be and there is no necessity of coming to the absurd conclusion that the astronomical unit of mass must have the dimensions $[L^3T^{-2}]$, as Maxwell does.

To further elucidate the matter, suppose that all bodies we are acquainted with had the same density—the maximum density of water say. Then the mass of a body would be directly proportional to its volume or $m = k''v$ in which m is the mass of a body, v its volume and k'' a constant. Now if we define our unit of mass as the mass of a unit of volume, $k'' = 1$ and $m = v$ from which according to the reasoning of physicists regarding the dimensions of force, we should conclude that the dimensions of m must be $[L^3]$. Of course in the above, k'' is the density—a certain number of units of mass per unit of volume—which multiplied by a volume would give a mass not a length cubed. If the numerical value of k'' be one, giving rise to the equation $m = v$, the latter simply means that the

number of units of mass in m is equal to the *number of units of length*, cubed, in v.

Instead of deploring the fact that the British and American engineer has used as a unit of force the pull of the earth on a certain quantity of matter, the writer believes it more unfortunate that the scientist did not use the pull of the earth on a mass of unit volume and density as the unit of force. Had this been done we should have the quantity W/g in place of m in all equations where m appears and the student would have little difficulty in understanding dimensions and could easily see whether the terms of an equation were all of the same dimensions or not, instead of having to assume the incorrect dimensions of a force given by physicists. In fact the unit of mass would not enter into any of the questions of terrestrial mechanics and mass would only be something through which the existence of force is made perceptible to the human mind.

What is W/g? It certainly is *not* mass, physicists to the contrary notwithstanding. This quantity has not yet been baptized correctly, but is worthy of a name. It is a quantity of the dimensions $[FL^{-1}T^2]$ *in fundamental units.* W is the pull of the earth on the matter we are dealing with at a point on the earth's surface where the acceleration due to gravity is g.

A REPORT ON THE ADMINISTRATION OF THE THURSTONE ENGINEERING APTITUDE TEST TO 800 STUDENTS IN THE COLLEGE OF ENGINEERING OF THE UNIVERSITY OF ILLINOIS.

The Mann Report on Engineering Education (1918)* speaks enthusiastically of the possibilities in the use of psychological tests to be given to engineering students, and in the spring of 1919 the faculty of the College of Engineering of the University of Illinois learned of the availability of the Thurstone Engineering Aptitude Test. Prior to this time the Bureau of Educational Research in the University had administered the Army Intelligence Test (Alpha) to all students in the University. Under the influence of these facts the faculty voted the appointment of a committee "to administer the Thurstone Engineering Aptitude Test to all students in the College of Engineering."

This commission was carried out, and it is believed that the results will be of value to other institutions and investigators who may be interested in this problem. Therefore, the committee in charge ventures to present in this article some of the facts, analyses, and conclusions, based upon the data secured.

Nature and Purpose of Psychological Tests.

Definitions.

It will be helpful, in order to make clear the purpose of the Thurstone Test, to distinguish between the various kinds of psychological tests which are now being used. These types include: (*a*) general intelligence tests; (*b*) tests of achieve-

* Bulletin XI. Carnegie Foundation for the Advancement of Teaching. By C. R. Mann.

ment; (*c*) trade tests; and (*d*) aptitude tests. These various types may be defined briefly as follows:

(*a*) *General Intelligence Tests* seek to measure an individual's ability to adjust his thinking quickly to a new situation; the Army Intelligence Test is an example of this type.

(*b*) *Tests of Achievement* attempt to measure in standardized units the quality of an individual's performance in a kind of school work in which he has become more or less proficient by practise. Courtis' Arithmetic Tests are examples of this type.

(*c*) *Trade Tests* are designed to determine in a very short time, the qualifications of a candidate for a given job; the Army Trade Tests are good examples of this type.

(*d*) *Aptitude Tests* attempt to measure the individual's inherent capacities which make for success is a given vocation or profession. This report deals with an example of this type.

Inasmuch as the Thurstone Aptitude Test is intended to be accompanied by a general intelligence test, that element in this study is supplied by the Army Intelligence Test. This latter test is probably not so well adapted to the purpose as those devised by Dr. Thurstone, but it is believed to be a good measure of general intelligence.

Valid Uses and Scope.

The valid uses of psychological tests as applied to students in engineering colleges are: first, to establish entrance requirements on a more rational basis than those now in use; second, to serve as personal ratings to administrators and teachers in dealing with students; third, to serve as a basis for educational and vocational advice to students.

The College of Engineering does not use entrance examinations to any extent, and therefore, the scope of this investigation is limited strictly to the determination of the merits of the tests in question as a reliable means of measuring the capacity of students to succeed in engineering subjects. The

only criterion by which engineering aptitude can now be judged is that of scholastic achievement as represented by college grades. Eventually it will be possible to compare the success of these men in the practise of their profession with their performance in the test. This criterion, is, of course, the one to be desired, but is not now available.

Materials Used.

The materials which provide the data for this report are as follows: first, Army Intelligence Test (Alpha); second, Thurstone Engineering Aptitude Test (1919); third, scholastic grades and averages of students; and fourth, instructors' ratings on all freshmen students.

Procedure.

The report of the administration of the Army Intelligence Test was published by the committee in charge,* and a summary of the results is shown in Table I. below. This test was administered several weeks before the Thurstone Aptitude Test.

The Thurstone Aptitude Test was administered to students in the College of Engineering on the afternoon of May 28, 1919, under very favorable conditions both from the standpoint of the students and the administrators. Eighty-five per cent. of the student body voluntarily took the test. The attitude of the men was serious, willing and even enthusiastic.

The nature of the aptitude test showed that it assumed a prerequisite of high-school physics. This college admits some freshmen who have not had this subject, and if the number of these students was considerable, it would have an important bearing on the results of this test. It was found upon investigation, however, that not over ten per cent. of the freshmen were handicapped in this regard, and moreover these students have had additional work in chemistry in lieu of

* Dr. D. S. Hill in *School and Society*, Vol. 9, No. 227, p. 542 to 545.

physics, and therefore, this deficiency could not be held to have an important effect up on the results of this test.

These facts assure us that each of these tests has been given a favorable opportunity to demonstrate its real value.

The papers of the Army Test were scored by trained clerks, according to Army regulations, under the supervision of the Bureau of Educational Research of the University. The papers of the Aptitude Test were scored by clerks under the supervision of the office of the Assistant Dean of the College of Engineering. There are 24 questions in the aptitude test which call for 32 separate responses. A student's score consists in a count of one point for each response; hence, a perfect score is 32. All responses were graded as right or wrong.

The instructors' ratings for all freshmen students were obtained by the separate rankings of two different instructors of each student who placed the man in one of ten groups, according to general ability and according to certain printed instructions.

The students' grades were obtained from grade cards kept in the college office.

DATA.

Array of Data Secured.

Table I below is a summary of the data secured in the Aptitude Test giving the high, low, and median* score for each class in each department. Table II is a compilation of the data concerning 100 freshmen taken at random, including grades in certain college courses. Table III gives the percentage of correct responses to each question, arranged by classes.

* See definition at bottom of Table I.

TABLE I.

Engineering Aptitude Test Summary of Scores.

Class.		Department.						
		Arch.	A.E.	C.E.	E.E.	M.E.	Others.	All Departments.
Fresh.:	*19	*31	*76	*92	*125	*21	*364
	High Score	28	27	29	29	29	23	29
	Low Score	4	6	6	4	2	6	2
	†Median	11	16	16	14	16	17	16
Soph.:	*10	*14	*25	*38	*27	*7	*121
	High Score	23	25	27	32	28	23	32
	Low Score	7	9	11	7	7	8	7
	†Median	15	17	18	16	20	14	17
Jun.:	*12	*14	*23	*26	*24	*13	*112
	High Score	25	28	30	30	30	29	30
	Low Score	4	9	8	11	14	11	4
	†Median	13	20	24	25	20	22	22
Sen.:	*7	*2	*15	*17	*16	*8	*65
	High Score	23		32	31	29	26	32
	Low Score	9		18	8	15	11	8
	†Median	16		26	22	25	17	23

* Number of men taking the test in the group.

† The Median is the mid-most score which indicates the point at which there were just as many men receiving a higher score as there were men receiving a lower score.

TABLE II.

DATA FOR 100 FRESHMAN SELECTED AT RANDOM.

Serial Number.	Unweighted Score.	Army Score.	Instructors' Rating.	Scholastic Average.	Academic Grades.		
					Plane Trig.	Analytic Geometry.	Descriptive Geometry.
368	13	159	6.0	3.64	3.0	...	4.0
230	19	162	9.0	3.07	3.0	3.0	4.0
151	19	156	8.0	4.20	5.0	...	5.0
2	16	133	9.0	3.82	3.0	4.0	4.0
24	15	139	7.0	4.16	5.0	4.0	5.0
66	12	126	10.0	3.90	5.0	4.0	5.0
193	6	108	...	2.06	...	...	...
89	23	152	3.0	3.61	4.0	4.0	4.0
130	15	147	8.0	2.42	3.0	3.0	2.0
209	14	125	6.0	3.03	4.0	3.0	3.0
91	22	139	8.0	3.61	4.0	3.0	5.0
233	26	154	10.0	4.81	5.0	5.0	5.0
71	18	157	6.0	3.64	4.0	4.0	5.0
222	10	127	8.0	2.21	5.0	...	2.0
4	25	160	8.0	4.23	5.0	5.0	4.0
409	17	107	8.0	4.28	4.0	5.0	5.0
407	20	143	5.0	3.45	4.0	4.0	4.0
74	15	160	...	3.08	2.0	3.0	4.0
229	19	174	8.0	3.84	...	3.0	5.0
30	18	159	...	2.89	5.0	...	4.0
158	11	145	7.0	3.06	4.0	4.0	3.0
134	17	123	5.0	2.84	...	3.0	4.0
77	27	163	8.0	4.32	4.0	5.0	5.0
7	17	127	8.0	3.81	...	4.0	4.0
94	2	87	5.0	1.23	1.0	...	2.0
204	15	158	4.0	1.36	1.0	...	2.0
3	17	184	8.0	4.26	5.0	4.0	5.0
92	16	131	6.0	2.00	4.0	...	2.0
116	17	109	8.0	3.44	...	...	...
42	18	144	8.0	2.92	3.0	...	4.0
76	17	121	8.0	3.58	5.0	4.0	4.0
25	14	71	8.0	4.64	5.0	...	5.0
192	16	126	6.0	3.61	2.0	4.0	3.0
141	18	133	5.0	2.83	5.0	2.0	5.0
351	16	149	8.0	3.87	5.0	4.0	4.0
370	8	77	8.0	2.72	4.0	...	4.0
382	26	155	5.0	3.22	3.0	2.0	...
375	29	196	6.0	3.88	5.0	1.0	5.0
257	12	140	6.0	2.93	3.0	4.0	4.0
374	18	149	7.0	2.85	...	2.0	4.0
300	21	171	6.0	4.03	5.0	4.0	5.0
869	8	136	5.0	2.50	1.0	...	1.0
291	25	158	6.0	3.87	5.0	4.0	4.0
398	16	167	...	3.80	4.0	...	4.0
388	20	136	6.0	3.03	5.0	3.0	4.0
268	11	125	8.0	3.60	4.0	2.0	5.0

THURSTONE ENGINEERING APTITUDE TEST.

TABLE II. (*Continued*).

Serial Number.	Unweighted Score.	Army Score.	Instructors' Rating.	Scholastic Average.	Academic Grades.		
					Plane Trig.	Analytic Geometry.	Descriptive Geometry.
256	9	125	6.0	3.14	...	...	4.0
284	13	166	9.0	3.23	4.0	3.0	4.0
103	25	173	10.0	4.53	5.0	5.0	5.0
235	24	168	8.0	4.38	5.0	4.0	5.0
128	13	105	8.0	3.45	5.0	3.0	5.0
237	20	155	4.0	2.93	1.0	...	4.0
123	22	128	5.0	3.31	3.0	3.0	4.0
329	22	167	7.0	3.07	3.0	2.0	2.0
338	22	128	...	3.07	4.0	3.0	4.0
347	22	143	7.0	3.64	4.0	4.0	5.0
324	29	171	10.0	4.68	5.0	5.0	5.0
311	15	156	5.0	2.20	4.0	1.0	2.0
327	15	143	8.0	4.32	5.0	5.0	5.0
325	18	112	6.0	4.57	5.0	5.0	5.0
277	20	132	6.0	2.17	2.0	1.0	2.0
289	22	130	4.0	2.96	2.0	...	4.0
367	10	123	8.0	3.23	4.0	3.0	4.0
132	12	130	6.0	3.37	3.0	4.0	4.0
124	13	131	6.0	2.72	2.0	3.0	3.0
245	8	135	1.0	2.13	1.0	...	2.0
335	19	134	10.0	2.92	4.0	...	5.0
305	9	139	4.0	2.50	2.0	...	3.0
279	26	158	6.0	2.13	2.0	...	3.0
281	15	118	6.0	2.53	3.0	3.0	2.0
267	19	173	4.0	3.12	4.0	4.0	3.0
259	19	151	7.0	2.56	3.0	...	4.0
248	17	170	7.0	3.14	4.0	3.0	4.0
247	18	158	7.0	3.45	5.0	...	5.0
140	14	157	6.0	2.81	3.0	3.0	3.0
118	13	166	3.0	1.74	1.0	...	3.0
294	21	128	8.0	3.74	4.0	...	5.0
266	11	121	8.0	3.00	2.0	...	5.0
168	14	137	3.0	2.00	3.0	1.0	5.0
87	8	125	6.0	2.65	3.0	...	4.0
137	16	155	9.0	3.54	4.0	4.0	3.0
27	10	118	9.0	2.30	3.0	1.0	3.0
33	20	190	8.0	3.16	4.0	3.0	4.0
63	21	159	2.0	2.81	2.0	...	3.0
26	28	132	8.0	3.94	5.0	...	5.0
84	7	143	6.0	2.87	4.0	...	4.0
214	5	183	3.0	1.83	...	...	1.0
224	15	152	7.0	4.16	...	...	4.0
218	20	173	8.0	4.22	...	4.0	5.0
408	25	181	3.0	3.48	3.0	5.0	4.0
352	21	157	...	3.23	4.0	3.0	...
216	11	104	6.0	2.97	4.0	2.0	3.0
285	11	126	4.0	2.65	3.0	3.0	4.0

TABLE II. (*Concluded*)

Serial Number.	Unweighted Score.	Army Score.	Instructors' Rating.	Average.	Academic Grades.		
					Plane Trig.	Analytic Geometry.	Descriptive Geometry.
64.....	13	159	8.0	4.57	5.0	5.0	5.0
227.....	23	179	4.0	3.93	3.0	3.0	3.0
32.....	14	135	8.0	2.43	5.0	...	3.0
11.....	22	123	4.0	2.43	4.0	3.0	3.0
166.....	13	146	5.0	3.42	5.0	4.0	4.0
194.....	11	152	2.0	2.74	4.0	4.0	2.0
144.....	9	145	2.0	1.83	2.0	...	2.0

TABLE III.

ENGINEERING APTITUDE TEST.

Question.	Freshmen			Sophomores			Juniors.			Seniors.		
	No. of Ans.	No. Corr. Ans.	% Corr. Ans.	No. of Ans.	No. Corr. Ans.	% Corr. Ans.	No. of Ans.	No. Corr. Ans.	% Corr. Ans.	No. of Ans.	No. Corr. Ans.	% Corr. Ans.
1..	359	224	62.4	120	77	64.1	112	75	67.0	65	49	75.5
2..	319	262	82.2	119	107	90.0	111	105	94.6	65	58	89.3
3..	359	181	50.4	119	78	65.5	112	76	68.5	65	48	73.9
4..	340	161	47.4	121	84	69.4	112	78	69.6	65	48	73.9
5..	340	176	51.8	112	66	58.8	107	77	72.0	64	46	72.0
6..	325	252	77.6	114	97	85.1	106	98	91.5	64	59	92.2
7..	330	207	62.8	111	77	69.4	106	76	71.6	63	50	79.4
8..	327	226	69.2	117	98	83.7	110	97	88.2	65	56	86.3
9..	325	74	22.7	115	30	26.4	109	69	63.3	63	42	66.6
10..	353	199	56.4	121	79	65.2	104	80	76.8	64	53	82.8
11..	323	225	69.6	110	79	71.8	97	72	74.3	61	49	80.4
12..	353	305	86.5	116	103	88.8	106	101	95.3	65	60	92.4
13..	289	206	71.4	109	92	84.4	103	90	87.3	61	56	91.8
14..	179	59	32.9	77	50	64.9	96	75	78.1	59	44	74.6
15 *a*	355	348	89.0	117	115	97.5	111	110	99.3	64	63	98.5
15 *b*	351	341	97.3	116	112	96.6	111	109	98.3	63	62	98.5
15 *c*	349	307	88.0	115	98	85.2	111	97	87.4	63	58	92.2
16..	265	90	33.9	75	31	81.4	82	36	43.9	54	25	46.4
17..	262	152	58.0	88	52	59.1	83	55	66.3	53	31	58.5
18 *a*	282	176	62.5	93	65	69.9	102	73	71.6	61	41	67.2
18 *b*	294	216	73.5	100	80	80.0	102	80	83.3	62	46	74.2
18 *c*	249	58	23.3	92	38	41.4	91	48	52.8	60	39	65.0
19 *a*	251	237	94.5	85	84	98.8	88	83	94.4	56	51	91.2
19 *b*	253	233	92.3	85	80	94.2	91	84	92.3	56	52	92.8
19 *c*	247	229	92.8	83	76	91.6	88	85	96.7	56	51	91.2
20..	199	70	35.2	68	24	35.3	86	34	39.5	50	23	46.0
21..	172	83	48.3	68	37	54.4	79	51	64.6	49	39	79.6
22 *a*	187	141	75.4	58	47	81.0	79	67	84.8	45	34	75.6
22 *b*	183	135	74.8	56	40	71.5	78	54	69.3	44	38	86.4
22 *c*	176	109	62.0	53	33	62.2	74	59	79.7	44	33	75.0
23..	121	84	69.4	40	32	80.0	59	49	83.1	40	34	85.1
24..	100	33	33.0	35	15	42.8	56	22	39.3	39	20	51.4

Analysis of Data.

1. *Freshmen.*—(*a*) It was noticed first, that of the 359 freshmen who attempted the first question in the Aptitude Test, exactly 100 men answered the last question. This condition offered good opportunity to determine whether in this test the rapid men were more or less accurate than the slower men. It may be noted that this use of these results would be incorrect unless each man attempted each question. This point was investigated, and it was found that these one hundred rapid men reached the last question only after attempting practically every question. Accordingly the precentage of correct responses of the 100 rapid men for each question was determined; also the percentage of correct responses of the other 259 slower men for each question was determined. The average percentage of correct responses for the rapid men was found to be exactly the same as for the slower group, namely 63.7 per cent.

(*b*) For determining the degree of relationship between performance in this test and in other work, it was decided to abridge the large amount of routine work required in securing the desired correlations, by making a random selection of 100 freshmen. This practise is commonly followed by statisticians, and a random selection of more than one fourth of the measures is believed to yield results that could not be different in any significant degree from the results of all measures taken.

(*c*) It was apparent that some questions were more difficult than others, and therefore, the question naturally arose as to whether or not the results should be weighted. This was done on the basis of the percentage of correct answers to each question, measured in probable error units. Each paper was then graded by the use of these weighted scores. The degree of relationship between the weighted and unweighted scores was then computed and found to be .99 where perfect correlation is represented by unity. Therefore, all subsequent correlations were based on unweighted scores.

(*d*) The matter of correlations will be discussed under three headings: first, definitions; second, mathematical assumptions involved; and third, enumeration and tabulation of the correlations secured.

1. *Definitions.*—The following statements from Whipple* may be taken as authoritative definitions of the term "correlation."

"Complete positive or direct correlation between two traits is present when the existence of the one is invariably accompanied by the existence of the other, or when increases of the one is invariably accompanied by corresponding and proportional increases of the other.

"Complete negative correlation is present when two traits are mutually exclusive, or when increase in the one is invariably accompanied by a corresponding and proportional decrease in the other.

"A correlation is indifferent or zero if the existence or variation of one trait is totally unrelated to that of the other.

"In perfect positive correlation, '*r*' (the letter used to denote the degree of correlation) is unity or 1.00; in complete negative correlation, '*r*' is —1.00; in indifferent or complete absence of correlation '*r*' is 0."

2. *Mathematical Assumptions.*—The assumptions on which the mathematical treatment of these data is based are: first, that the achievements in these tests may be represented without important error by the probability curve, or the curve of error; second, that large enough numbers have been used to give valid measures of the reliability and value of the tests in question.

That these assumptions are entirely warranted may be shown by the following evidence. Fig. 1 represents the distribution diagram for 100 freshmen taken at random. This diagram reads "Four freshmen made a score of 8, three made a score of 10, six made a score of 11, etc." Fig. 2 represents a similar diagram for the entire freshmen class. It is noticed

* Whipple, G. M., "Manual of Mental and Physical Tests, Simpler Processes," p. 36.

that the latter curve approximates very nearly the curve of normal distribution, and also that the curve representing 100 men chosen at random compares very closely with the curve for the larger group.

The same evidence presented in a little different form by the use of a percentile curve is shown in Fig. 3. The full line represents the curve for all freshmen; the dotted line is the curve for 100 freshmen taken at random. This curve is read as follows for the dotted line: a score of 16 in the Aptitude

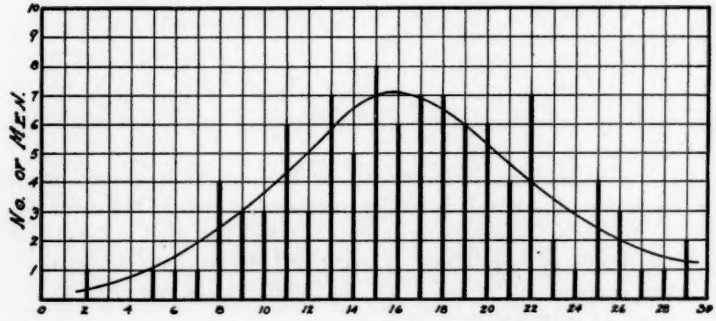


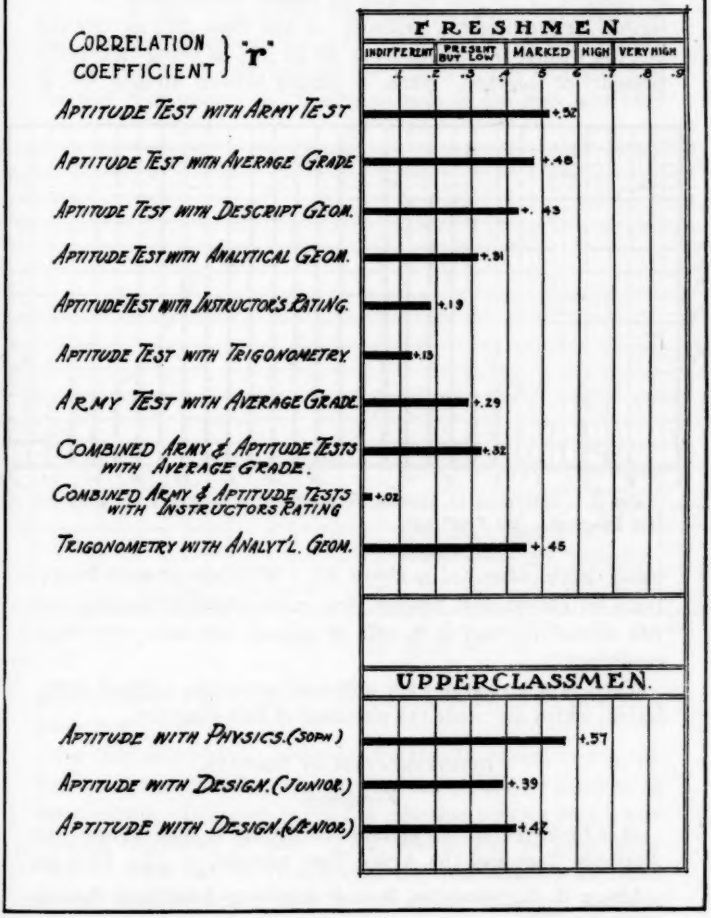
FIG. 1. University of Illinois, Engineering Aptitude Test. Distribution Diagram for 100 Freshmen Selected at Random.

Test was surpassed by 50 per cent. of these men; a score of 24 was surpassed by 10 per cent. of these men; etc.

The shape and similarity of these curves verify the validity of the above assumptions.

(3) *Enumeration and Tabulation.*—The correlations which have been computed and the results secured are shown in Diagram A. One of the "scatter diagrams" which represents these correlations is shown in Diagram B. The correlation coefficient "r" has been defined above, but the comparative importance of different values of 'r' is not so evident. For example, the significance of a positive correlation of say .5 can not be said to be twice as great as a correlation of .25.

DIAGRAM "A"


CORRELATION COEFFICIENT "r"
FRESHMEN
INDIFFERENT
PRESENT BUT LOW
MARKED
HIGH
VERY HIGH
.1
.2
.3
.4
.5
.6
.7
.8
.9
APTITUDE TEST WITH ARMY TEST
+.52
APTITUDE TEST WITH AVERAGE GRADE
+.48
APTITUDE TEST WITH DESCRIPT GEOM.
+.43
APTITUDE TEST WITH ANALYTICAL GEOM.
+.31
APTITUDE TEST WITH INSTRUCTOR'S RATING.
+.19
APTITUDE TEST WITH TRIGONOMETRY.
+.13
ARMY TEST WITH AVERAGE GRADE.
+.29
COMBINED ARMY & APTITUDE TESTS WITH AVERAGE GRADE.
+.32
COMBINED ARMY & APTITUDE TESTS WITH INSTRUCTORS RATING
+.02
TRIGONOMETRY WITH ANALYT'L. GEOM.
+.45
UPPERCLASSMEN.
APTITUDE WITH PHYSICS. (SOPH.)
+.57
APTITUDE WITH DESIGN. (JUNIOR.)
+.39
APTITUDE WITH DESIGN. (SENIOR.)
+.42

The large amount of experience in dealing with this class of data has led one investigator to the following statement.*

"The experience of the present writer in examining many correlative tables has led him to regard correlations as 'negligible' or 'indifferent' when '*r*' is less than .20; as 'present but low' when '*r*' ranges from .20 to .40; as being 'markedly present' or 'marked,' when '*r*' ranges betwen .40 and .60; as

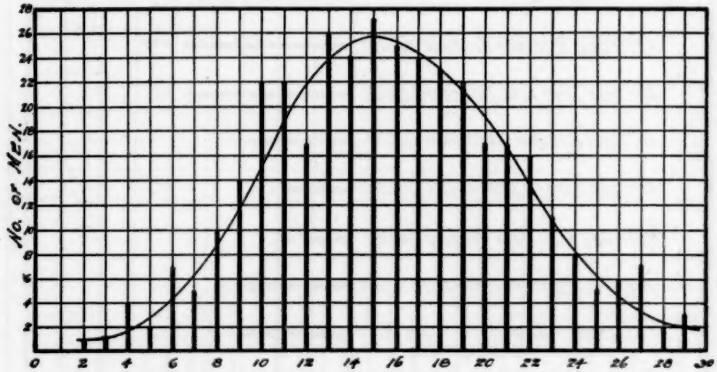


FIG. 2. University of Illinois, Engineering Aptitude Test, Distribution Diagram. 359 Freshmen.

being 'high' when '*r*' is above .60. With the present limitations on educational testing, few correlations in testing will run above .70, and it is safe to regard this as a very high coefficient."

The characterizations are indicated above the units of correlation, which are made the abscissae of this diagram.

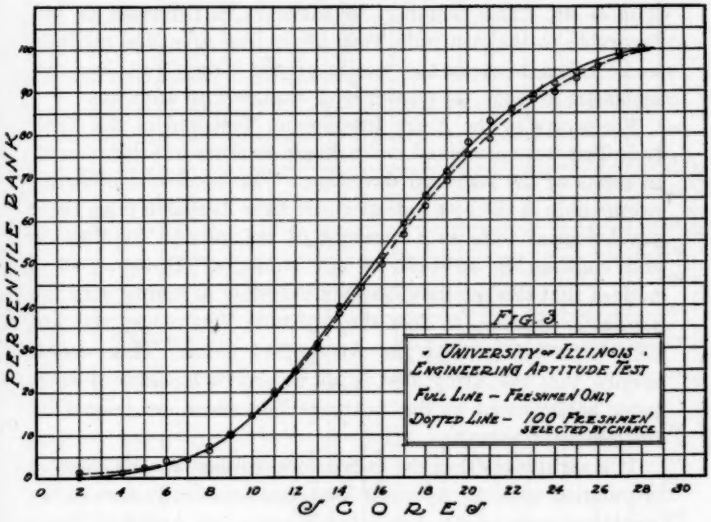
INTERPRETATION OF RESULTS.

Freshmen.

It is noticed that the highest correlation is that between the Aptitude Test and the Army Test, namely, + .52. This in-

* Rugg, H. O., "Statistical Methods Applied to Educational Measurements," p. 256.

dicates clearly that the qualities required for success in the one are largely present in the other. The second highest correlation is noted between the Aptitude Test and Scholarship, namely, + .48. The Army Test is avowedly an intelligence test; devised, of course, for a very different class than college men, and yet the distribution curve for college students and the fact that women did nearly as well as the men, are very



good evidence that it has the distinctive qualities of an intelligence test.

On this assumption, however, we should except the Army Test to correlate rather highly with the scholastic average of our students. But such is not the case, for here we find a correlation coefficient of only + .29, which may be said to be "low." This can be interpreted only to mean that those mental qualities which make for success in freshmen subjects are not so greatly in evidence in the Army Test, as in the

Aptitude Test. It should be said further, that achievement in college subjects is modified by very different qualities than general intelligence; *e.g.*, laziness in bright pupils, and industry in dull pupils, etc.

The Aptitude Test, however, seems to call into activity qualities which make for success both in the Army Test and in scholastic work; for, as noted above, its correlation with the Army Test is highest + .52 and with the scholastic average it is + .48. This fact may be taken to be favorable or unfavorable to the Aptitude Test, depending upon the attitude to be taken towards the merits of the Army Test and the scholastic average, as measures of engineering aptitude.

The scores in the Army Intelligence Test and in the Aptitude Test were combined into a single measure of achievement, in terms of the standard deviation. This combined measure, presumably is the best indication we have available from these psychological tests as a measure of the general intelligence and engineering aptitude of our students. However, it is noticed that this measure does not correlate as highly with the scholastic average, as does the Aptitude Test alone, and but very little better than the Army Test alone. This means, simply, that the Army Test is not so good a measure of scholastic achievement as the Aptitude Test alone, as judged by the scholastic average.

It is significant that the instructors' ratings are very low in correlation with the Aptitude Test, and practically zero in the combined score of the Army Intelligence and Aptitude Tests. This may be explained by remembering that one's impression of a student's general ability is a composite of a large number of very important traits of character, and indeed, Professor Mann makes the claim that "technical information"—the basis of scholastic success—is only one fourth as important as human qualities, which form a basis for rating in general ability. However, too much weight should not be given to results of the tests in connection with the instructors' ratings in this study, because of the fact that these ratings were based on a

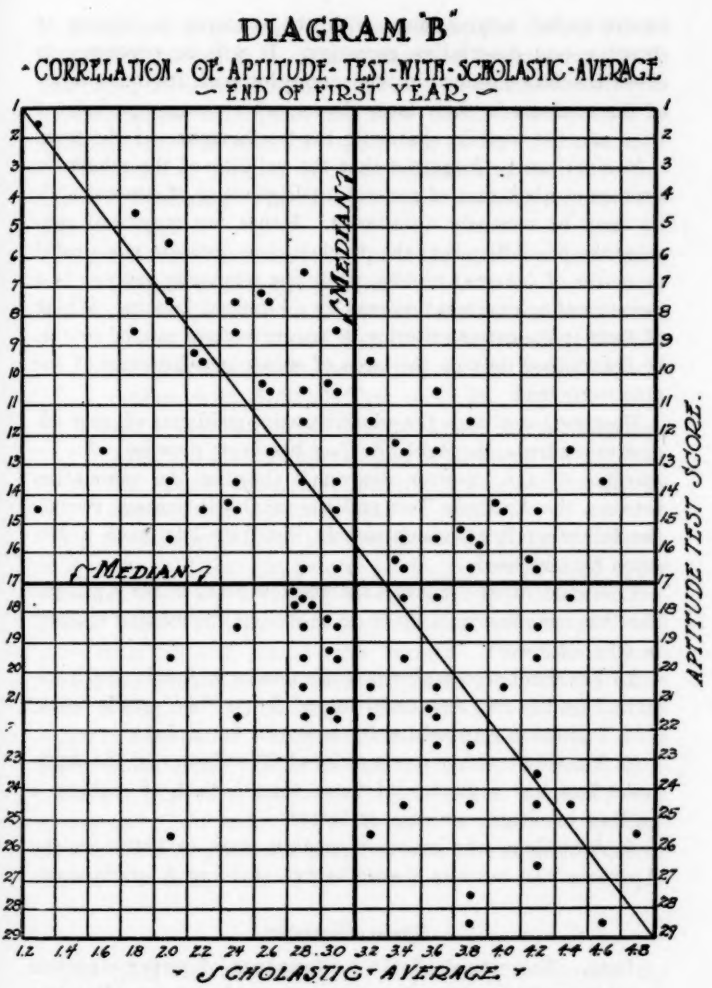


DIAGRAM "B"
CORRELATION OF APTITUDE TEST WITH SCHOLASTIC AVERAGE
END OF FIRST YEAR
MEDIAN
MEDIAN
APTITUDE TEST SCORE.
SCHOLASTIC AVERAGE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48

DIAGRAM B. Correlation of Aptitude Test with Scholastic Average, End of First Year.

twelve-weeks' acquaintance with the students in classes of drawing and descriptive geometry. It will be necessary to check the data obtained in this connection with further studies of the students in their later classes, where longer periods of time may be used in observing the performance of the men.

It must not be forgotten that the validity of the scholastic average as a measure of general intelligence or of general ability may be seriously questioned. Hence, we may well consider the possibility that the psychological tests are more valid measures of *inherent ability,* while the scholastic average is a measure of achievement colored by a hundred factors. Which of these is the better criterion of future success can, of course, be determined only on the basis of subsequent histories of the men concerned.

However, as a basis for administrative guidance of, and advice to students, the Aptitude Test has more promise. An inspection of the "scatter diagram" showing the correlation between the Aptitude Test and the scholastic average reveals the following facts, which merely illustrate how such a diagram may be used:

1. A student who makes a score as low as 10 in the Aptitude Test has one chance in ten to do as well as the median student in scholastic work.

2. A student who makes a median score or less in the Aptitude Test has one chance in ten of doing "A" grade work. ("A" grade is represented by numerals 4.2 to 5.0.)

3. A student who makes a score of 20 or better in the Aptitude Test has a chance of more than 5 to 1 of making a median scholastic average or better.

4. A student who makes a median score or better in the Aptitude Test has one chance in five of doing A grade work.

Upper Classmen.

Data.—The record of the performance of upper classmen on this test was secured to serve as evidence regarding the merit of the Aptitude Test, as judged by the grades of the

students in courses in physics, mechanics, and design courses which are deemed to be better criteria of engineering ability than the grades in freshman studies. The courses chosen were selected on the assumption that these, more than any other in college work, represent the engineering ability of the men.

Treatment of the data for upper classmen is similar to that used for freshmen. The results of these correlations are summarized below:

1. *Sophomores.*—Correlation of average grade in Laboratory Physics with Aptitude Test = + .57.
2. —*Juniors.*—Correlation of average grade in Architecture, Architectural Engineering, Civil Engineering, Mechanical and Electrical Engineering design and laboratory courses, with Aptitude Test = + .39.
3. *Seniors.*—Correlation of average grade in Architecture, Architectural Engineering, Civil Engineering, Mechanical Engineering and Electrical Engineering design courses, with Aptitude Test = + .42.

On the assumption that the courses chosen are good criteria, it must be said that the results of the performance of upper classmen are very favorable to this test. The "scatter diagrams" show that the test discriminates between good and poor students with considerable success. The men in these classes are undoubtedly a more intelligent group on the whole than freshmen, because they represent the survival of the fittest to some extent. Moreover, nearly all of them have made applications of the principles used in the test in many classroom and laboratory exercises; both of which facts impose a severe test of the test. Yet, it seems to be nearly as discriminating between good and poor students in the case of upper classmen as in the case of the freshmen.

Conclusions.

The facts and analyses given above seem to warrant the following conclusions: First, that there is no difference in accuracy of results as between the rapid and the slower men.

The rapid men simply having accomplished more work in a given time; second, that the Aptitude Test is a better measure of probable success of students in engineering courses, than the Army Intelligence Test; third, that the Aptitude Test is very discriminating in the upper and lower regions of ability; fourth, that if the facts exhibited here should be verified by further observations, the test would be very useful in advising exceptionally good and poor students and their parents regarding their probable success in engineering studies.

In view of the problem raised by the study of the committee in charge of this investigation, the faculty has voted to continue the studies by having the dean's office observe the progress of the men who have taken the tests, especially the freshmen, and by having reports made each year upon the results secured. Further provision has been made for a study of the use of psychological tests in other institutions by the appointment of a permanent committee of the college, which is to make recommendations and carry out investigations from time to time.

EDITORIAL.

What constitutes a good meeting? This question is uppermost in the minds of the committee at Yale who are planning for the 1921 meeting. They recognize that good papers and addresses are essential; that discussion of such provide an opportunity for the general exchange of ideas, but they believe that there is something better than help for everyone who attends the annual meeting and that is the opportunity of meeting and talking with old friends and making new ones. The committee with this in mind is planning to have ample opportunity and excellent facilities for social intercourse. The Program Committee is coöperating and we may expect as a result that the program for the 1921 meeting will have less time devoted to prepared papers and formal discussions, and more to the interchange of ideas in small groups.

The Secretary was a visitor at Yale recently and found the forthcoming meeting of the Society looked forward to with eagerness by the Yale faculty. If enthusiasm and good planning count, we may expect as large and influential a meeting as that at Michigan which was the largest ever held.

The Program Committee would like suggestions in regard to the program for the 1921 meeting to be held at Yale University June 28 to July 1.

Dues. The members of the Society will be interested in knowing that the Treasurer has paid all back bills of the Society. On December 1, there were no outstanding bills. Of course, the largest bill of the present year has not been paid, namely, the bill for the *Proceedings*. These will shortly be mailed to members.

The second bill for dues has been sent to all who did not pay upon receipt of the first notice.

We need two hundred new members. Are you doing your share?

COLLEGE NOTES.

Iowa State College, Ames, Iowa. *Additions to Engineering Faculty.*—Agricultural Engineering: J. A. STARRAK, assistant; past 6 years teaching farm mechanics at MacDonald College, Quebec, Canada, with title of lecturer in agricultural engineering. W. T. ACKERMAN, fellow; grad. Conn. State College, 1920; inst. past year there. Q. C. AYRES, assistant professor; fills vacancy caused by resignation of D. P. Weeks; grad. Univ. of Miss., 1912, Bachelor of Engineering Professional degree, C.E., 1920; 1912–15, drainage work in Miss. and Ark.; 1915, highway construction and hydro-electric development in Miss. and Ala.; 1916–19 drainage engineer, Bureau of Public Roads, U. S. Dept. of Ag.; 1919–20, asst. prof. civil engineering, Univ. of Miss.; 18 months overseas, 1st Lt. Engrs., serving with combat divisions. ARTHUR W. TURNER, assistant professor (non-coll); fills vacancy caused by resignation of C. K. Shedd; graduate of Ames, B.S. in A. E., '17; been working on Ag. Eng. Ext. staff past year.

Ceramic Engineering: PAUL E. COX, associate professor; grad. Alfred Univ., '05; 8 years inst. at Newcomb College, New Orleans, La.; last with Pittsburgh Grinding Wheel Co.; takes place of O. J. Whittemore, who has gone into commercial work.

Chemical Engineering: O. R. SWEENEY, professor, head of department; B.S., in Chem. Eng., Ohio State, 1909; M.S. in Chemistry, Ohio State, 1910; Ph.D. in Chemistry, Univ. of Penn., 1916; instructor, Univ. of Penn., six years; inst., chem. eng. dept. at Ohio State, 1916–17; chief assistant to Colonel McPherson in Chemical Warfare Service; last professor of chem. eng. at Univ. of Cincinnati.

Civil Engineering: ALMON H. FULLER, professor, head of department; grad. La Fayette College, '87; 18 years dean of engineering, Univ. of Washington; last director of engineering

at La Fayette College; was associated with Gustav Lindenthal on design of Hell Gate Arch over East River in New York; worked with C. E. Fowler on the redesign and strengthening of the Niagara River railroad arch bridge; was a member of the commission which revised the building code of the city of Seattle. FRANK KEREKES, assistant professor; B.S., College of City of New York, 1917; C.E., Columbia Univ., 1920; undergraduate inst. at both above institutions; fills vacancy left by H. F. Clemmer; in charge of drawing. NORMAN F. GODFREY, instructor; B.S., in C. E., Univ. of Pittsburgh, 1919; 1 year draftsman, Pennsylvania Rubber Co.; fills vacancy left by C. H. Schuman, in drawing dept. J. N. COOK, instructor; B.S. in C. E., Ames, 1916; assistant city engr., Ames, now; fills vacancy left by V. R. Ewing in surveying dept.

Electrical Engineering: L. F. WOOD, associate professor; grad., Penn State, '13; 3 years with Western Electric; 1 year, inst. Univ. of Okla.; 2 years, inst. Chicago Central Station Institute; fills vacancy of H. C. Bartholomew, who goes to Ill.; Northern Utilities Company, Dixon, Ill., as distribution engineer. E. W. SCHILLING, instructor; grad., Univ. of Ill., '19; 1 year General Electric Co.; 6 months electrician for Goodrich Rubber Co.; fills vacancy of T. C. Dee. WARD B. KINDY, instructor; grad., Ohio State, '16; 1 year gunnery instructor naval aviation; 3 years Engr. Electric Controller & Mfg. Co., Cleveland; fills vacancy of N. L. Towle.

Engineering Extension Department: VERNE L. HEIN, assistant professor of Engineering Extension; grad., Ames, B.S. in E. E., '18; 2 years construction engineer., Iowa River Light & Power Co.; 1½ years Fort Wayne Elec. Co.; fills vacancy of A. B. Campbell, who has gone with Iowa Railway Commission. R. S. WALLIS, professor of civil engineering.; grad., Ames, B.S. in E. E., '07, B.S. in C. E., '11; formerly in charge of C. E. drawing here, 6 years; 3 years at Univ. of Mo. in charge of drawing. J. V. LYNN, associate professor, vocational education; grad., Stout Institute; fills vacancy of K. G. Smith, who

goes to Lansing, Michigan, as director of trade and industrial education, State Board of Vocational Education.

Mechanical Engineering: ANDREW MAITLAND, instructor; comes from Waterloo to fill vacancy of R. C. Riedesel. C. E. HANSON, assistant professor; grad., M. I. T., '14; fills vacancy of H. T. Woodward, who has gone into commercial work. T. B. HINES, instructor; 7 years inst. in blacksmithing at Anamosa reformatory; takes Roy Fitzjarrell's place. H. V. PETERSON, student assistant; junior M. E. student; takes place of H. M. Larsen, who will give full time to college work.

Physics Department: P. L. BROWNELL, assistant; taught physics in Fort Madison High School last year; takes place of Irving Wolff.

Engineering Problems Department: C. W. BEESE, instructor; grad., M. E. Dept., Ames, '15; last with Teeter Adding Machine Co., Des Moines.

Trades and Industry Department: ADOLPH SHANE, professor and head of department; B.S., in E.E., Univ. of Neb., 1901; professional degree E.E., Ames, 1908; instructor, Univ. of Penn., 1903–04; asst. prof. E. E., Ames, 1904–08; assoc. prof. E. E., Ames, 1908–12; dean of engineering, Highland Park College, Des Moines, 1912–17; in government service, 1917–19; dean of engineering, Des Moines College (formerly Highland Park), Des Moines, 1919–20. WILLIAM H. FLOOD, instructor; Univ. of the City of New York, 1900; has been employed as designer and production engineer by Westinghouse Electric & Mfg. Co., Remington Arms & Ammunition Co., General Motors Co., and the Ordnance Department of the Government. VIRGIL GUNDER, instructor in auto mechanics. HARLEY J. NETHKEN, instructor; B.S., in E. E., Highland Park College, '15; instructor, Des Moines (Highland Park) College, 1919–20.

Massachusetts Institute of Technoloy. *Changes in Instructing Staff, 1920–21.*—Promotions—to the grade of professor: Assoc. Prof. C. W. Berry to professor of heat engineering; Assoc. Prof. H. W. Gardner to professor of architectural

design; Assoc. Prof. H. W. Hayward to professor of materials of engineering; Assoc. Prof. C. L. E. Moore to professor of mathematics and research; Assoc. Prof. J. C. Riley to professor of adviser for mathematics, heat engineering.

To the grade of associate professor: Asst. Prof. Edward Mueller to associate professor of inorganic chemistry; Asst. Prof. J. W. Phelan to associate professor of inorganic chemistry; Asst. Prof. R. E. Wilson to associate professor of chemical engineering, director of the research laboratory of applied chemistry, beginning April 1, 1920.

To the grade of assistant professor: Instructor H. L. Bowman to assistant professor of structural engineering; Instructor Tenney L. Davis to assistant professor of organic chemistry; Instructor J. J. Eames to assistant professor of experimental engineering; Instructor W. F. Jones to assistant professor of structural geology; Instructor F. R. Kneeland to assistant professor of organic chemistry; Instructor C. W. Ricker to assistant professor of electrical engineering.

To the grade of instructor: Assistant James Holt to instructor in mechanical engineering; Assistant E. F. Nelson to instructor in mechanical engineering; Assistant C. L. Svenson to instructor in mechanical engineering.

The executive committee has agreed to consolidate the department of geology and geological engineering with the department of mining engineering and metallurgy, under the title "Department of Mining, Metallurgy and Geology," the consolidation to be effective for administrative purposes beginning with July 1, 1920. The personnel of the combined department is as follows:

Waldemar Lindgren, William Barton Rogers professor of economics geology; in charge of the department.

Heinrich O. Hofman, professor of metallurgy; in charge of the option in metallurgy.

Charles H. Warren, professor of mineralogy; in charge of the course in general science and general engineering.

Hervey W. Shimer, associate professor of paleontology.

Charles E. Locke, associate professor of mining engineering and ore dressing.

Edward E. Bugbee, assistant professor of assaying and metallurgy.

Carle R. Hayward, assistant professor of metallurgy.

William F. Jones, assistant professor of structural geology.

The department of drawing and descriptive geometry has been re-classified as a division of the department of architecture in charge of Professor W. H. Lawrence, the re-classification to become effective on July 1, 1920.

Professor A. E. Burton has been appointed dean of students, and his appointment as professor of topographical engineering will be continued.

Professor C. H. Peabody is to retire on October 1, 1920, and the executive committee has conferred upon him the title of professor emeritus.

Professor James R. Jack has been appointed head of the department of naval architecture and marine engineering upon the retirement of Professor Peabody.

The executive committee has voted that the registrar be designated as a member of the faculty, classified as an associate professor.

The committee also voted that in the future Mr. Humphreys' title be "registrar" instead of "registrar and recorder."

Harold W. Bibber has been appointed exchange instructor in electrical engineering to the Ecole Centrale Paris, France.

The institute has turned over to the students of the electrical engineering coöperative course, a house at 95 Newbury Street, which has been remodeled and equipped as an up-to-date club where the students in the coöperative course may live while they are at the institute. The General Electric Company maintains a similar clubhouse for these students at Lynn. Both houses are controlled and operated by a house committee from among the members of the course.

This housing arrangement not only prevents a loss of time

which would otherwise be experienced when the students are exchanging places between the General Electric works and the institute, but also provides assembly rooms where evening lectures are given.

University of Nebraska. Faculty changes include the following appointments: J. D. Parsons, instructor in agricultural engineering; E. W. Carlton, instructor in applied mechanics; Professor Clark E. Mickey becomes chairman of the civil engineering department; John G. Mason, assistant professor of civil engineering; M. I. Evinger, associate proefssor of civil engineering; Wm. H. Pahl, instructor in civil engineering; Ferris W. Norris, instructor in electrical engineering; E. G. Nazarene, assistant professor of mechanical engineering.

At the **Pennsylvania State College** the current year opened with an enrollment in all departments of 2,949 students, of whom 1,101 were in the school of engineering. The distribution between the several departments follows:

Department.	Seniors.	Juniors.	Sophomores.	Freshmen.	Total.
Architectural Engineering	6	6	14	12	38
Civil Engineering	23	63	48	50	184
Electrical Engineering	69	98	127	136	430
Industrial Engineering	36	40	60	38	174
Mechanical Engineering	49	56	61	86	252
Total regular students	183	263	310	322	1,078
Special students					23
Total in School of Engineering					1,101

Late enrollments have brought the total number of students in the school of engineering to approximately 1,150. It was necessary to refuse about 1,100 applications for admission, distributed through all the departments of the college, because of lack of housing space in the village and of class room and laboratory facilities in the college.

The changes in the faculty of the school of engineering are as follows:

The department of architectural engineering lost A. W. Emerson and M. E. Cressley, instructors in engineering drawing. New appointments are Joseph T. Larkins and David A. Campbell, instructors in engineering drawing, and H. O. Smith, assistant in engineering drawing. Mr. Larkins comes from the Phœnixville, Pa., plant of the American Bridge Co., and Mr. Campbell from one of the shipbuilding corporations.

The civil engineering department lost none of its faculty permanently, but W. W. Patchell, instructor in civil engineering, is away on leave of absence, and is now assistant engineer in the office of the division engineer of the Conemaugh Division of the Pennsylvania R. R. located at Pittsburgh, Pa. Raymond O'Donnell, associate professor of hydraulic and sanitary engineering, who has been absent on leave for work in the engineering division of the Pennsylvania Department of Health, has returned to his college duties. H. G. Curtis has been appointed assistant in civil engineering.

The department of electrical engineering lost H. A. Brown, instructor in electrical engineering, who accepted a similar appointment at the University of Illinois. He is replaced by M. J. Maxfield, instructor in electrical engineering, who comes here from Cornell University.

The industrial engineering department has all of its staff of last year. P. R. Hall returned from a year's leave of absence with the Aluminum Castings Co., Detroit, to resume his duties as instructor in forging and foundry.

The department of mechanics and materials of construction lost E. B. Cassel, instructor. New instructors appointed are W. R. White, W. M. Reid and P. B. Kapp, with F. T. Vansant student assistant.

The department of mechanical engineering lost W. H. Martin, associate professor of mechanical engineering, who accepted an appointment as professor of experimental engineering with the Oregon Agricultural College, and V. W.

Hewlett, assistant professor of mechanical engineering who went to Michigan Agricultural College. New appointments are C. C. Cochran, O. K. Harlan and W. G. Thompson, assistant professors of mechanical engineering, and W. H. Reish and C. H. B. Hotchkiss, instructors, with R. H. Roberts student assistant.

The new power plant to replace the one partially destroyed by fire in November, 1918, is practically completed. The boiler plant has been completely modernized, all boilers raised 4 ft. 6 in. and complete new settings built, and entirely new systems of steam and water piping installed. The boilers are Keeler and Babcock and Wilcox, all equipped with Taylor stokers. The steam pressure will be 150 lbs. with 125° superheat. The generating room is entirely new, the main units being two 300 K. W. alternates driven by General Electric turbines. Distribution throughout the college is alternating current, motor generator sets being used wherever direct current power is required.

Work on the new mechanical engineering laboratory is being pushed rapidly, and it is expected that this building will be ready for occupancy early in the spring. A somewhat complete description will be submitted for a later issue of the BULLETIN.

Purdue University.—The regular work of instruction at Purdue University started on September 8 this year. The attendance is considerably larger than it was last year, the number of students registered in the several engineering schools being given in the accompanying tabulation.

School.	Fresh.	Soph.	Jr.	Sr.	Special.	Total.
Chemical Engineering	111	89	58	44		302
Civil Engineering	121	119	75	61	1	377
Electrical Engineering	198	172	79	56	1	506
Mechanical Engineering	210	210	110	67	5	602
						1,787

A number of changes have occurred in the faculty personnel. Dean C. H. Benjamin retires this year under the provisions of the Carnegie Foundation, and while as yet he retains his position as director of the Engineering Experiment Station, he has given up his work as Dean of the Engineering Schools. Dean A. A. Potter of the Kansas State Agricultural College has been appointed Dean and has already taken active charge. Dean Potter is now busily engaged with the numerous administrative problems which have arisen with the greatly increased attendance.

The school of electrical engineering has been fortunate in that it has been able to maintain its teaching staff practically intact. C. W. Piper, instructor, resigned last spring to enter the commercial field as an electrical jobber and contractor. The vacancy has been filled by the appointment of J. B. Bailey, transformer engineer of the Duncan Electric Company, Lafayette, Indiana. Previous to his employment with the Duncan Company, Mr. Bailey spent a number of years in the transformer design departments of the Westinghouse Electric and Manufacturing Company and the General Electric Company. K. B. McEachron, research assistant in the Engineering Experiment Station will administer a course in advanced electrical theory this year and has been appointed instructor in electrical engineering. Previous to his connection with the engineering Experiment Station, Mr. McEachron was head of the electrical department at Ohio Northern University. In the School of Civil Engineering, Ben. H. Petty, Purdue '13, formerly with Morgan Engineering Company, Miami Conservancy Project, in charge of certain portions of the highway engineering and construction work, has been appointed instructor in civil engineering and will devote a considerable portion of his time to highway engineering extension work. L. S. Gaston has been appointed instructor in the materials testing laboratory.

Several changes have occurred in the school of mechanical engineering. Professor O. C. Berry has resigned to enter the

employment of the Hupmobile Company of Detroit, Michigan. Professor T. T. Eyre has been given leave of absence on account of ill health and is now located in Albuquerque, New Mexico. R. E. Hundley, instructor, has resigned to enter manufacturing work in St. Louis. Professor M. R. Hammer, formerly of Northwestern University, has been appointed associate professor of mechanical engineering. H. S. Jones, H. W. Bonis and J. A. Needy have been appointed Instructors in mechanical engineering and P. C. Hockema has been appointed assistant in the mechanical laboratory.

Four additional shop instructors have been added to the staff of the department of practical mechanics. Frank McGrath, Purdue '11, has been appointed instructor in drawing, in charge of advanced drawing. Mr. McGrath was previously employed as testing engineer, Carnegie Steel Company, Pittsburgh, Pennsylvania. This department is now giving instruction to about one thousand students in the shops and six hundred and fifty students in the drawing rooms.

In the department of applied mechanics, an additional instructor, W. B. Sanders, has been employed. The school of civil engineering has inaugurated a new orientation course, for freshman students. This course aims to provide: (1) A general survey of the field of the civil engineer, (2) The historical development of the civil engineering profession, (3) A series of engineering projects of a simple character. Lectures by various members of the faculty constitute part of the work of this course while the prefect work is under the direction of Professor W. A. Knapp.

In the school of electrical engineering, increased stress has been given the business side of engineering by changing the course in corporate organizations from a three-hour per week elective course to a five-hour per week required course. The school is also coöperating with the military department of the university by administering special courses in military communications to the advanced students in the motorized field artillery unit.

The school of mechanical engineering is administering for the first time, courses in aviation and aërodynamics and is also coöperating with the Military Department by giving instruction on motor-car construction and gas-engine operation to all students in the field artillery unit.

A new tractor testing plant forms an important addition to the testing equipment of the school of mechanical engineering. This plant, which has just been placed in operation, is one of the most complete of its kind.

The 600,000 volt equipment in the high voltage laboratory of the school of electrical engineering is now complete and is being used in high-voltage research work.

The department of practical mechanics has added a number of machine tools to its equipment. In the main these were purchased at government equipment sales.

The Engineering Experiment Station is now carrying on four major researches:

The fixation of atmospheric nitrogen.
Standardization of tractors.
Carburators and carburation.
Indiana sands and gravels.

The work on nitrogen fixation has been in progress a couple of years and a preliminary report on the work done was made by Professor C. Francis Harding and K. B. McEachron at the joint meeting of the American Institute of Electrical Engineers and the American Electrochemical Society, held in Boston last April. Further results will be published probably in the form of a bulletin of the Engineering Experiment Station. The research on carburation is described in a bulletin by Professor O. C. Berry, now in press.

The research in Indiana sands and gravel is under the direction of Dr. W. K. Hatt, of the school of civil engineering.

In addition to the major researches noted above a number of other researches are in progress or have just been completed. Dr. Hatt has been investigating the effects of the coarse sands, so prevalent in Indiana gravel pits, on the

strength of concrete and also has made some elaborate tests in determining the best operating conditions for a well-known type of concrete mixer. Prof. F. W. Greve has completed on parabolic weirs, the results of which will be made public in the form of a paper presented before one of the engineering societies. Professor R. V. Achatz has completed an investigation on the preservation of wooden poles in Indiana. The results of this investigation are now available in the form of a circular of information published by the Engineering Experiment Station.

University of South Dakota.—Additions to the teaching staff of the engineering department of the University of South Dakota have been made by the election of Mr. E. L. Clark as associate professor of civil engineering, and of Mr. E. O. Slater as instructor in shop work; their duties beginning with the opening of the present school year.

Mr. Clark comes to the University from Westinghouse, Church, Kerr and Co. He has had broad training in the practice of civil engineering, which will make him a valuable addition to the teaching staff.

Mr. Slater comes well recommended as a shop instructor, and served during the past school year as superintendent of shops at the Agricultural and Mechanical College of Texas.

New Shops at the University of South Dakota.—The engineering department of the University of South Dakota was established in 1902; but due to a number of causes has possessed no building that could be called its own until the past year when the new engineering shops were completed and occupied.

The plan for the housing of the engineering comprises a three unit building of rough face brick. The first or front unit will contain the class rooms, drafting rooms, and offices. Located in the rear of this and in the order named, will be

the general engineering laboratory and shops units. The units will be connected by covered passage-ways.

The shops, with the exception of the central part which is two stories, are one story high. The first floor is occupied by the work rooms, offices, lavatory, and general tool room; all of which are built around a corridor of generous proportions. The second story of the central part of the building is used for shop class and storage purposes. The total floor space in the building is roughly thirteen thousand (13,000) square feet.

The rooms devoted to machine shop and wood shop work have each about 2,700 square feet of floor space, with an equipment consisting principally of belt driven machinery of the general type found in such shops. The lathes in the machine shop run from 14″ to 26″ swing.

The forge and foundry each occupy floor space of about 2,400 square feet. The former is equipped with down draft forges which are connected to the blast and exhaust fans by means of reinforced concrete ducts. The equipment for the foundry has not as yet been purchased, but it is the intention to use a cupola of the tilting type.

The engineering department of the university supplies all tools used by the students; and fully equipped individual tool lockers are provided throughout the shops, the locker plan of tool supply being found very much more satisfactory where efficient tool room help is lacking. The tool room is used only for general tools and machine equipment.

It is the hope of those interested in engineering that the state legislature will, in the very near future, appropriate funds for the erection and equipment of the remaining units of the engineering building.

The **University of Virginia** enters upon its ninety-seventh session with a record matriculation. Already over sixteen hundred students have registered and indications point conclusively to an attendance of nearly eighteen hundred for the session.

The engineering department has registered approximately two hundred twenty-five, with a falling off in Freshman compared with last session.

For the first time in its history the university has admitted women to its regular courses. Admission of women is confined to the professional schools and graduate department. Eighteen young ladies are at present in attendance.

The additions to the faculty of the engineering department incliude Mr. Edward W. Saunders, adjunct professor of applied mathematics, who has been for some years at the University of South Carolina in civil engineering; Wilfred Eldred, associate professor of business administration, who was for several years connected with the Harvard School of Commerce; and James S. Miller, Jr., instructor in experimental engineering.

Several changes have been necessitated in order to accomodate the increased numbers in engineering. All machine and wood work has been moved from the engineering building to temporary quarters in the commodious shop and garage erected for use with the Army Training School. Temporary quarters for all draughting work have been arranged by making use of one of the Army barracks after moving it to a convenient location near the engineering building. These changes have made available much needed class room space and have given to the department of electrical engineering a doubled floor space.

Elaborate preparations are being made for the centennial celebration of the founding of the university. These exercises will be held May 31 to June 3, inclusive, 1921, and indications seem to assure a celebration hitherto unequalled in the South. An interesting and important feature of the celebration is the centenary birthday gift from alumni and friends, which is expected to amount to three million dollars. This gift, whose completion is to be announced as the culminating feature of the celebration, will be applied partly for new buildings, including an engineering building, partly for endowment for

increasing salaries and for new chairs and partly for endowment of the alumni secretary office.

Work is well under way at present on a Greek amphitheater and stadium, a gift to the university from Mr. Paul Goodloe McIntire, an alumnus and a native of Charlottesville. This structure which will house a magnificent pipe organ will be unique and will be finished in time for use at the centennial.

Agricultural and Mechanical College of Texas. *Civil Engineering Department Staff Changes.*—The Civil Engineering Department, of the A. & M. College of Texas, begins the session of 1920–21 with nearly three fourths of its teaching staff composed of new men. The only holdovers in the Department are J. C. Nagle, professor of civil engineering; J. J. Richey, professor of structural engineering; Byron Bird, associate professor of highway engineering.

The new men in the Department are:

W. J. EMMONS, professor of highway engineering (succeeding Mr. Roy M. Green, who is now manager of the Western Laboratories at Lincoln, Nebraska), comes to the Civil Engineering Department from the Birmingham office of the Pittsburgh Testing Laboratory, where, as assistant to the director of the Department of Roads and Pavements, he was in charge of the testing and approval of road materials and the design, preparation and construction of asphaltic pavements.

Mr. Emmons received the degree of Sc.B. in Civil Engineering from Brown University in 1912 and that of A.M. in Highway Engineering from Columbia University in 1914. Since that time he has had a broad experience, both in contractors organizations and state highway work, especially along the lines of laboratory examinations testing and control of bituminous and other materials for highway and street construction.

B. D. MARBURGER, associate professor of railway engineering, succeeds Mr. A. C. Love, who has resigned to accept a

position as division engineer with the Texas State Highway Department.

Mr. Marburger graduated from the civil engineering course at the Agricultural and Mechanical College of Texas in 1905, since which time he has been connected with the Sunset-Central Railway Lines, St. Louis, Brownsville & Mexican Railway, San Antonio & Aransas Pass Railway and Missouri, Kansas & Texas Railway, as general foreman, assistant and district engineer.

T. A. MUNSON, who comes to the Civil Engineering Department as assistant professor of civil engineering, graduated from the civil engineering course, A. & M. College of Texas, in 1910.

Mr. Munson was assistant highway engineer for Fort Bend County, 1910–1911, since which time he has held the positions of engineer on sanitation and installation of water supply, topographer and designer for reclamation and drainage projects, chief engineer for drainage district and highway engineer for road districts in Brazoria County, Texas. In addition he has had an extended general civil engineering practice.

J. L. LOCHRIDGE, civil engineering department, as instructor in civil engineering for the year 1920–1921.

Mr. Lochridge graduated from the civil engineering course at the Agricultural and Mechanical College of Texas in 1910. He has had a wide experience in various engineering works, especially in irrigation and drainage, his last position being that of assistant engineer and superintendent of duty of water in irrigation investigations, United States Department of Agriculture, coöperating with the Texas State Board of Water at Mercedes, Texas.

J. T. L. MCNEW, who has been employed as instructor in the civil engineering department, graduated from the civil engineering course at this college in June, 1920.

After Mr. McNew graduated he was employed in the office of Mr. Oscar A. Seward, city engineer of Beaumont, Texas, where he had a varied experience which will be of great help

to him in his teaching work at this institution. He also had considerable experience in directing concrete construction work prior to his graduation, and in handling soldiers of war in highway construction and repairs in France.

C. C. BRADEN has been employed as instructor in civil engineering. He graduated from the civil engineering course of this college in 1919. After graduation he was with the State Highway Commission of Illinois during the summer of 1919. At the opening of the fall session he came to the college as instructor in drawing, holding this position until the close of the school in June, 1920, after which time he was on the engineering force of Mr. W. C. Youngs, county highway engineer, Polk County, Texas.

Electrical Engineering Appointments on the Teaching Staff of A. & M. College, of Texas.—J. W. RAMSEY, associate professor of electrical engineering, comes to the institution from Washington State College at Pullman, Washington. J. H. STAUDT, associate professor of electrical engineering, comes from commercial work with the government in one of their larger powder plants at Nashville, Tennessee. J. H. SECHRIST, assistant professor of electrical engineering, comes from the Louisiana Industrial Institute, at Ruston, La. C. C. YATES, assistant professor of electrical engineering, comes to the college from service with the Westinghouse Electric and Manufacturing Company, at East Pittsburgh, Pa. L. L. FORAKER, instructor in electrical engineering, comes from Dallas, Texas, from commercial work. He was formerly with the Westinghouse Electric & Manufacturing Company, at East Pittsburgh, Pa. R. D. BLUMBERG, instructor in electrical engineering, graduated at the A. & M. College of Texas, in June, 1920.

Chemistry and Chemical Engineering Appointments on the Teaching Staff of A. & M. College, of Texas.—F. H. FISH, associate professor of analytical chemistry, has been connected with research work for the engineering foundation, University of Illinois. He comes directly from Illinois to the department. F. R. J. PARKINSON, instructor in agricultural chemistry, has

had one year of graduate work at Texas A. & M. College. L. A. KOENIG, instructor in general chemistry, comes to the department from the department of chemistry and physics, Houston High School. H. S. HARPOLE, instructor in general chemistry, comes from Chambersburg, Illinois, where he was superintendent of schools.

Architectural Department.—H. N. JUNE, instructor in architecture, comes to the department of architecture from private practice at Cincinnati, Ohio.

Textile Engineering.—L. E. DOWD, associate professor of textile engineering, comes to the department of textile engineering from a cotton office in the United States Army. C. JENNINGS, instructor in textile engineering, has been sent to this department by the Federal Board as instructor for federal students.

Mechanical Engineering.—L. S. WATON, associate professor of mechanical engineering, comes to this department from Queens University, Ontario, Canada. L. K. LAURSEN, instructor in wood shop of this department, comes from the South Dakota, A. & M. College, Brookings, South Dakota. A. J. KUNZE, instructor in machine shop of this department comes to the college from Cameron, Texas. W. C. HUTTON, instructor in mechanical engineering, comes to this department from Monticello, Indiana.

Yale University.—Recent events of interest have been:

Reorganization of the entire university faculty along departmental lines. This resulted in the formation of a division of engineering, one of the four divisions into which the entire university faculty is divided. The division comprises six departments of engineering with Professor J. C. Tracy as chairman.

The creation of a department of engineering mechanics under Professor C. J. Tilden, formerly of Johns Hopkins University.

The formation of a so-called "common" freshman year,

with a separate dean and faculty. Professor Roswell P. Angier is the new dean of freshmen, and the faculty is composed of men notably successful as teachers. Incoming freshmen no longer enter Yale College or the Sheffield Scientific School, but the freshman year of Yale University. There are three groups of studies in the freshman year, preparatory respectively to courses which lead to the B.A. and Ph.B. degrees in Yale College and to the B.S. degree in the Sheffield Scientific School; included in the last group are those students who expect to study engineering. English and European History are required of all Freshmen. Prospective engineering students are expected to elect in their freshman year also chemistry, mathematics, mechanical drawing and introduction to engineering. Actual choice of engineering is not necessarily made, however, until late in the year.

The lengthening of the course in the Sheffield Scientific School to four years. For all engineering students the work of the first two years is common; differentiation begins only with the Junior year. The Sheffield Scientific School is now "the university's undergraduate school for professional study in science and engineering."

The inauguration of a course in administrative engineering, designed to prepare men for executive positions for which a knowledge of engineering principles and methods is requisite, rather than for work in design and construction. The curriculum includes thorough training in the fundamental sciences and engineering, and in subjects relating to business, beside general studies. During the last two years some elective courses are provided. A large number of students are already enrolled in the course.

The growth of engineering in the graduate school. Last year the group of engineering graduate students numbered 48. This group (or division) outnumbered every other group in the graduate school. Instruction in engineering in the graduate school during the past year has included courses of lectures by visiting engineers prominent in their profession.

Twelve courses of three to five lectures each were provided by special action of the corporation. The list of lectures and their general subjects follows. Some of the lectures conducted conference courses following their lectures.

In Civil Engineering.

Charles J. Bennett, State Highway Commissioner of Connecticut,
"Highway Engineering."

George W. Fuller, Consulting Engineer, New York,
"Sewage Disposal."

O. E. Hovey, Assistant Chief Engineer, American Bridge Company, New York,
"Bridge Design."

Fred Lavis, Consulting Engineer, American International Corporation, New York,
"Economic Railroad Location and Construction."

In Electrical Engineering.

William McClelland, Consulting Engineer, New York,
"Engineering Phases of Public Utilities."

L. F. Morehouse, Equipment Development Engineer, American Telephone and Telegraph Company, New York,
"Electrical Communication."

F. D. Newbury, Engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh,
"Design of Electrical Machinery."

Percy H. Thomas, Consulting Electrical Engineer, New York,
"Electrical Power Transmission."

James W. Welsh, Special Engineer, American Electric Railway Association, New York,
"Electrical Transportation."

In Mechanical and Electrical Engineering.

George A. Orrok, Consulting Engineer, New York,
"The Development and Design of Power Plants."

R. J. S. Pigott, Consulting Engineer, Bridgeport,
"The Operation of Power Plants."
William S. Murray, Consulting Engineer, New York,
"The Distribution and Use of Power."

This list does not include a large number of lectures delivered during the year by practicing engineers, many of them alumni of the university. Some of these lectures have been given under the auspices of the student branches of the national engineering societies.

Increase in the acreage of the large tract of land used as a summer camp. Several hundred acres have recently been purchased so that the total area is now about 1,800 acres, the extreme length about 3½ miles and the greatest width 2½ miles. Camp buildings have already been designed and it is hoped that construction will begin shortly. A four weeks course in surveying is prescribed for all students in the engineering group at the close of their freshman year.

The activities of the Yale Engineering Association. This association composed of some 1,000 alumni of the university has coöperated with the faculty and officers of the university in the recent reorganization, and in plans for future development. It issues during the year a number of booklets, called news letters, and a compendious year book.

The acceptance by the Society of the university's invitation to hold the 1921 convention here. Plans for making this a memorable occasion are already being formulated.

Professor C. F. Scott spent the summer in Europe as a consulting engineer on Italian electrification projects.

Professor C. J. Tilden spent the greater part of the summer in Washington, D. C., where he was engaged in an advisory capacity to the chief of the Bureau of Public Roads.

Messrs. W. J. Cox and W. A. Wood, Jr., instructors in engineering mechanics, have resigned, the one to engage in construction work, the other to accept a commission in the Corps of Engineers, United States Army.

Professor W. K. Shepard has accepted a position with an industrial laboratory with headquarters in New York City.

Mr. Ira T. Hook, University of Michigan, 1913, newly appointed assistant professor of engineering mechanics, will have charge of the work in testing materials. Professor Hook has been with the testing department of the General Motors Company since graduation, with the exception of the two years of war, when he was in command of the United States Ordinance School for Engineers of Test at Pittsburgh.

Mr. R. H. Skelton, Yale, 1909, S., has been appointed instructor in engineering mechanics. Mr. Skelton has just returned from China, where he spent three years teaching in the Imperial Pei Yang University at Tien Tsin. Previous to this he was for several years instructor in civil engineering in the Sheffield Scientific School.

Mr. Thomas K. Hendrick, senior instructor in the department of engineering mechanics, will have charge of the newly established laboratory of elementary mechanics.

Mr. Philip G. Laurson, Massachusetts Institute of Technology, 1910, was during last year appointed assistant professor of engineering mechanics. Professor Laurson has had a varied experience in structural work, ship building and teaching.

Mr. G. F. Allen was added to the electrical engineering staff this fall. Mr. Allen is a graduate of Toronto University, has had several years' experience in industrial design and control work, and taught at Lafayette College for two years.

Professors H. V. Bozell and L. W. W. Morrow were engaged on editorial work for the *Electric Railway Journal* during the summer. Professor Bozell continues as an editor of the paper, but retains his connection with the department of electrical engineering.

Professor H. M. Turner, of the department of electrical engineering, gave during the summer a number of lectures to army officers at Camp Vail, on radio telegraphy.

Mr. F. M. Gracey was recently appointed instructor in the

department of engineering drawing. He has taught the subject for a number of years past at the Massachusetts Institute of Technology. Previously he taught at the state college in Massachusetts and Michigan.

Plans are being prepared for a new building for the department of chemistry, which has hitherto carried on its work partly in the Kent Chemical Laboratory and partly in the Sheffield Chemical Laboratory. The new building will probably be located on the Pierson-Sage Square just north of the physics laboratory, where amply space is available. It will have a total floor area of 100,000 square feet and in addition to the usual laboratories and recitation rooms will include an ample number of rooms for research work, as well as space in which it will be possible to develop a process from the laboratory investigation up to a small-sized commercial scale. The laboratory will afford every facility for the development of the new course in industrial and engineering chemistry.

SECTIONS.

At its first meeting of the year (October 19) the Georgia Tech Section of the S. P. E. E. elected officers, as follows:

President: R. S. KING, Professor of Experimental Engineering.

Vice-President: T. G. SELDELL, Associate Professor of Electrical Engineering.

Secretary-Treasurer: R. R. KIRK, Assistant Professor of English.

A paper was presented by Professor Seidell.

Dr. D. S. Elliott, former president of the Georgia Tech Section, is now professor of physics at Tulane University, New Orleans.

R. R. KIRK,
Secretary.

OBITUARY.

SAMUEL SHELDON.

Dr. Samuel Sheldon, professor of physics and electrical engineering at the Polytechnic Institute of Brooklyn for the past 31 years, died September 4, at the Addison House, Middlebury, Vt., which town was his early home.

Dr. Sheldon was born in Middlebury on March 8, 1862, the son of Harmon Alexander and Mary Bass Sheldon. He was graduated from Middlebury College in 1883 with the degree of A.B. and then pursued graduate work, receiving the degree of A.M. in 1886. During the next two years he studied at Wurzburg, Germany, and received the degree of Doctor of Philosophy there in 1888. During a part of this time he was associated with Kohlrausch, the distinguished physicist, in his celebrated determination of the ohm as the unit of electrical resistance. He was awarded the honorary degree of Doctor of Science from the University of Pennsylvania in 1906, and from Middlebury College in 1911.

Dr. Sheldon came to the Polytechnic Institute in Brooklyn in 1889, after a year spent at Harvard as instructor of physics, and upon his coming he was honored with a full professorship in physics and electrical engineering. He was then in his 27th year. His thorough command of his subjects, together with the enthusiasm and energy which he exhibited in the lecture room, gained for him a reputation as one of the foremost educators in the engineering profession. His strong points as a teacher were his inspiring and sympathetic personality, keen analytical mind, executive and coöperative ability, and tremendous capacity for work. Illness in 1909 necessitated a long vacation, and he chose to spend it in a trip to Europe, where he had an opportunity to visit the

principal engineering schools of Germany, the British Isles, France and Italy.

Dr. Sheldon was the author and joint author of several college textbooks. Among them were "Direct-Current Machines," "Alternating-Current Machinery," "Electric Traction and Transmission Engineering" and "Physical Laboratory Experiments." He had also written a number of monographs and papers on special topics.

Dr. Sheldon was an honorary fellow of the American Electro-therapeutic Association, fellow and past president of the American Institute of Electrical Engineers, member of the American Physical Society, member and past president of the New York Electrical Society, member of the American Electro-Chemical Society, member of the Society for the Promotion of Engineering Education, member, assistant treasurer and past vice-president of the United Engineering Society and chairman of its library committee, member of the Brooklyn Institute of Arts and Sciences and president of its department of electricity, member of the Engineers Club, ϕ B K and Δ K E fraternities.